for Steve

Special Report

Results of the General Adjustment of the North American Vertical Datum of 1988

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ABSTRACT. *For the new general adjustment of the North American Vertical Datum of 1988 (NAVD 88), a minimum-constraint adjustment of Canadian-Mexican-U.S. leveling observations was performed holding fixed the height of the primary tidal benchmark, referenced to the new International Great Lakes Datum of 1985 (IGLD 85) local mean sea level height value, at Father Point/Rimouski, Quebec, Canada. IGLD 85 and NAVD 88 are now one and the same. Father Point/Rimouski is an IGLD water-level station located at the mouth of the St. Lawrence River, and is the reference station used for IGLD 85. This constraint satisfies the requirements of shifting the datum vertically to minimize the impact of NAVD 88 on U.S. Geological Survey mapping products, and provides the datum point desired by the IGLD Coordinating Committee for IGLD 85. The only difference between IGLD 85 and NAVD 88 is that IGLD 85 benchmark values are given in dynamic height units, and NAVD 88 values are given in Helmert orthometric height units. The geopotential numbers of benchmarks are the same in both systems. Preliminary analyses indicate differences for the conterminous United States between orthometric heights referred to NAVD 88 and to the National Geodetic Vertical Datum of 1929 (NGVD 29) range from −40 cm to +150 cm. In Alaska, the differences range from +94 cm to +240 cm. However, in most "stable" areas, relative height changes between adjacent benchmarks appear to be less than 1 cm. In many areas, a single bias factor, describing the difference between NGVD 29 and NAVD 88, can be estimated and used for most mapping applications. The overall differences between dynamic heights referred to IGLD 85 and to International Great Lakes Datum of 1955 will range from 1 cm to 40 cm. The use of Global Positioning System (GPS) data and a high-resolution geoid model to estimate accurate GPS-derived orthometric heights will be directly associated with the implementation of NAVD 88 and IGLD 85. It is important that users initiate a project to convert their products to NAVD 88 and IGLD 85. The conversion process is not a difficult task, but will require time and resources.*

History of U.S. National Geodetic Vertical Datums

The first leveling route in the United States considered to be of geodetic quality was established in 1856-57 under the direction of G.B. Vose of the U.S. Coast Survey (predecessor of the U.S. Coast and Geodetic Survey and, later, the National Ocean Service). The leveling survey was required to support current and tide studies in the New York Bay and Hudson River areas. The first leveling line officially designated as "geodesic leveling" by the Coast and Geodetic Survey followed an arc of triangulation along the 39th parallel. This 1887 survey began at benchmark A in Hagerstown, Maryland.

By 1900, the vertical control network had grown to 21,095 km of geodetic leveling. A reference surface was determined in 1900 by holding elevations referenced to local mean sea level (LMSL) fixed at five tide stations. Data from two other tide stations indirectly influenced the determination of the reference surface. Subsequent readjustments of the leveling network were performed by the Coast and Geodetic Survey in 1903, 1907, and 1912 (Berry 1976).

The next general adjustment of the vertical control network was accomplished in 1929. By then, the international nature of geodetic networks was well understood, and Canada provided data for its first-order vertical network to combine with the U.S. network. The two networks were connected at 24 locations through vertical control points (benchmarks) from Maine/New Brunswick to Washington/British Columbia. Although Canada did not adopt the "Sea Level Datum of 1929" determined by the United States, Canadian-U.S. cooperation in the general adjustment greatly strengthened the 1929 network. Table 1 lists the kilometers of leveling involved in the readjustments and the number of tide stations used to establish the datums. Figure 1 depicts the U.S. portion of the primary network used in the 1929 readjustment.

Analyses of NGVD 29 General Adjustment

It would have been helpful to the NAVD 88 datum definition study to recreate the 1929 general adjust-

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Table 1. Amount of leveling and number of tide stations involved in previous readjustments.

Year of Adjustment	Kilometers of Leveling	Number of Tide Stations
1900	21,095	5
1903	31,789	8
1907	38,359	8
1912	46,468	9
1929	75,159 (U.S.)	21 (U.S.)
Calif. had tide guage at this pt	31,565 (Canada)	5 (Canada)

U.S. Coast and Geodetic Survey

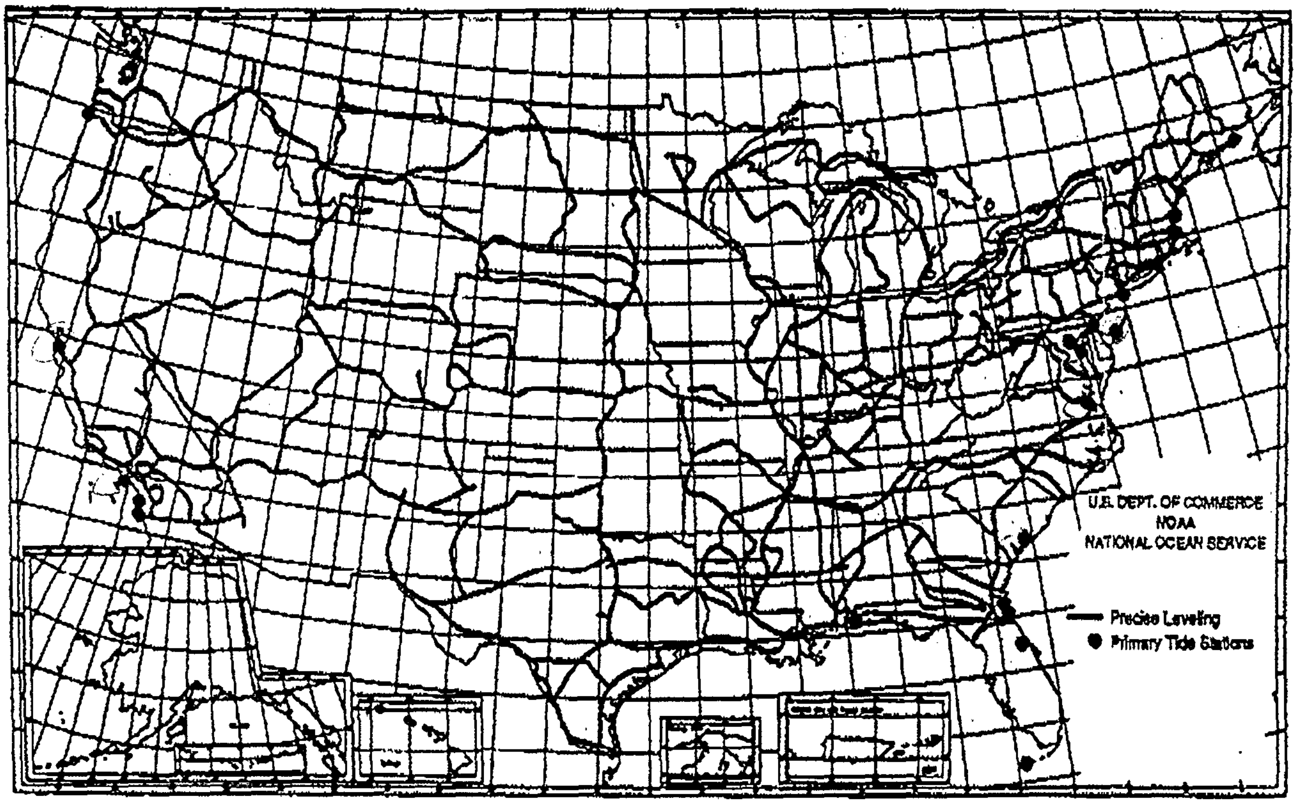

Figure 1. First-order vertical control used in 1929 adjustment.

ment using geopotential differences. This was not possible, because most of the original data used in the NGVD 29 adjustment were not placed in computer-readable form. Many of the original leveling lines were releveled, and because the old leveling was not essential to the readjustment project, these older data were not automated.

However, in support of NAVD 88, the National Geodetic Survey (NGS) Vertical Network Branch (VNB) converted the historic height difference links involved in the 1929 general adjustment to computer-readable form. The 1929 general adjustment was re-created by constraining the heights of the original 26 coastal stations. Free-adjustment results were then